best way is to mount them with the short side down, soldering them to the printed line or emitter track as appropriate and the *opposite side* to the top groundplane. Make sure that the other side of the capacitor (the track side) does not short to the groundplane: check this with an Ohm-meter. The correct way of fitting them is given in **Fig 5.** Carefully fit the trimmer capacitors making sure that they are fitted the right way round (adjusting slot or rotor connection to ground), sitting flush on the board with minimum lead length.

Solder in transistors and IC's last, using a minimum of heat (shortest soldering time possible). The oscillator transistors *must* have their screen leads soldered to the groundplane using the minimum lead length. The flatpack transistors should fit in the mounting holes with their leads flush to the tracks. Any excess lead length should be trimmed off before soldering: make sure their orientation is correct! Similarly for the transistors on the amplifier board, not forgetting that the final amplifier transistor in this case must be heat-sinked before testing and use. Using a diecast box, the stud of the transistor may be bolted to the box bottom when the PCB is mounted in the box. If you align the board out of its box, bolt on about four square inches of ⅛in thick aluminium plate to the stud. It is difficult to use a tinplate box for the amplifier as the thin tinplate will not provide heatsinking.

A properly "engineered" and housed oscillator a multiplier source should look like the photograph on the opening page.

ALIGNMENT OF MICROWAVE CIRCUITS

As was pointed out in the original articles, alignment is best undertaken using simple test equipment in the first instance: absorption wavemeters rather than frequency counters and analogue meters rather than digital meters.

Try to follow the procedures described *exactly*: the alignment methods were as carefully thought-out as the circuits! It will pay you to acquire or make simple wavemeters covering about 90 to 600MHz in order to check that the various multiplier stages are on the correct frequency. A wavemeter and some form of simple power detector usable at the output frequency is also useful to have, some designs are given in the fourth edition of the *VHF/UHF Manual*. Calibration of wavemeters can be carried out at Microwave Round Tables and sometimes you may find suitable wavemeter-power indicators as surplus equipment at rallies.

CONCLUSIONS

Microwave construction need not be either daunting or unsuccessful, although some simple do's and don'ts should be observed, as outlined in this review. Follow the 'rules' as described in the supporting articles and you won't go far wrong!

Good luck with your construction and don't forget that members of the Microwave Committee are usually available (via RSGB HQ) to offer advice and assistance in case of difficulty. □

REFERENCES

1. 'A local oscillator source for 1152MHz', Sam Jewell, G4DDK, "Microwaves", *RadCom*, February and March, 1987.
2. 'A 1W 1152 to 1300MHz linear amplifier', Sam Jewell, G4DDK, RSGB Microwave Newsletter, 07/87 (October-November) 1987.

A low pass filter for HIGH power

George Eddowes, G3NOH, describes a simple and effective filter for HF QRO.

Ever since I started using a linear amplifer on the HF bands, my low pass filter has not been in the correct position in the chain of my equipment because it was made for a maximum output of about 200 watts. Recently, a complaint of slight TVI spurred me on to make a filter that would handle the full legal power, in fact the item to be described is capable of handling well over 400 watts!

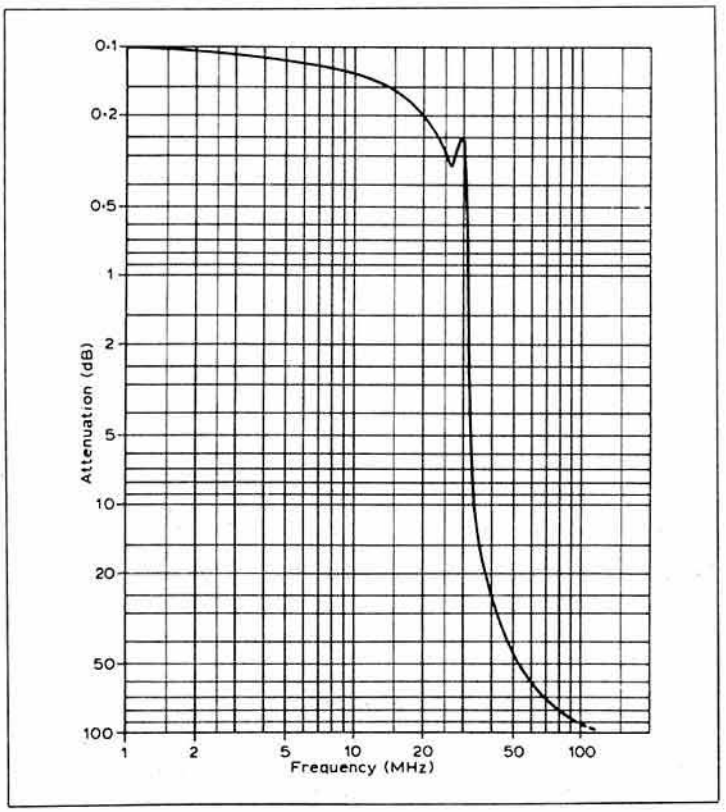
The values for the components were taken from an article by I4QQE/F0BJT which appeared in *RadCom* in December 1978. The problems associated with making a filter which is capable of handling a large amount of power centre around the type of capacitor that needs to be used, together with the close tolerance that is required of it. The method employed here overcomes both of these snags and, provided one has the basic skills in using a few handtools, the design can be easily reproduced with the same characteristics as shown in the response curve. Since I designed and constructed this filter, I have been informed that the same capacitor construction was used in an age-old low-pass filter made by the 'Minimitter Company' of London.

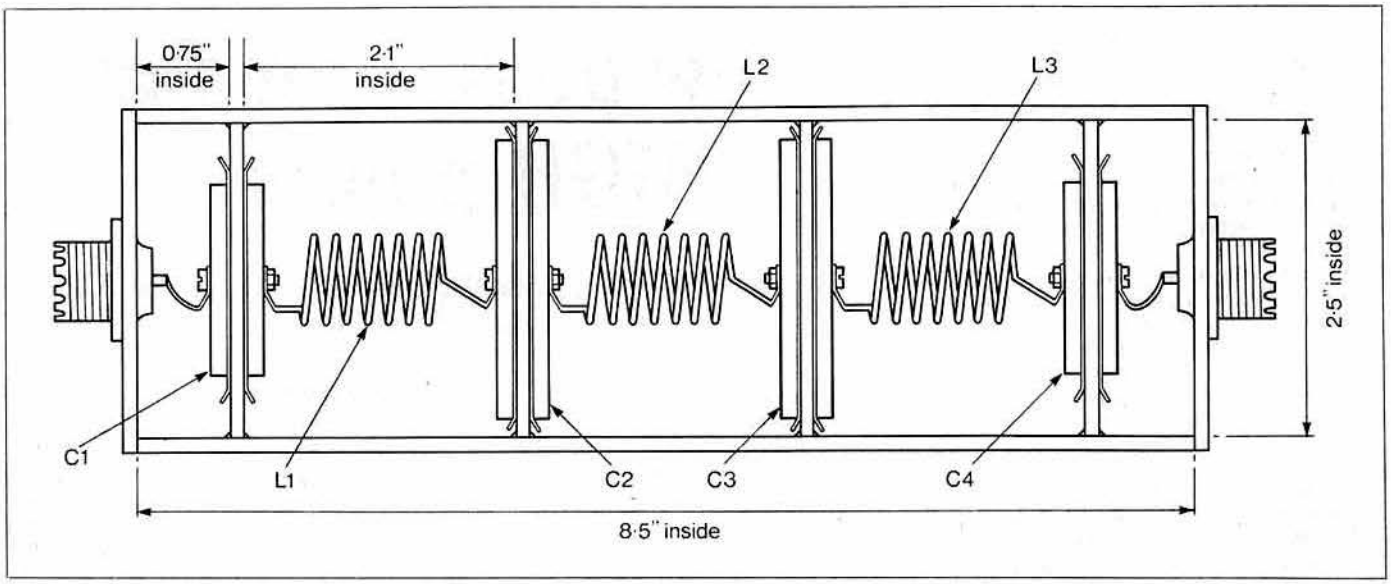
CONSTRUCTION

The housing uses 2mm double-sided copper-clad glass fibre board which makes assembly relatively easy when using a soldering iron. The capacitors are made using ⅛" dural sheet, which ensures no mechanical distortion and 10thou PTFE sheet, which provides a dielectric capable of withstanding very high voltages. **Fig 1** shows the dimensions of the filter and **Table 1** gives the dimensions of the component parts. **Fig 2** is an exploded view of the capacitor assembly.

The end screens are drilled so as to accommodate whatever connectors are preferred by the builder. The screens are then all drilled and reamed in their centre to enable a spacer, fabricated from the inner insulation of UR67 coax cable, to make an interference fit. The spacers are cut to just under the thickness of the PCB and a No. 32 drill is used to open up the hole to clear a 6BA screw. At this point it may be worthwhile mentioning that the easy way of locating the exact centre of a screen is to draw two lines joining the opposite diagonal corners and where they intersect is the spot! Using a large drill, say ½" to ¾", and/or a

Attenuation curve of low-pass filter.





modelling knife, remove the copper from around the hole for about 1/10" and remove any burrs that may be on the edges of the boards.

Tin all the edges of all the boards for about 3/16", taking care not to deposit too thick a layer of solder. A convenient method to ensure this is to wipe the solder while it is still molten. Remember that all the screens need to be tinned on both sides.

Assemble the base, one of the sides and the middle screen, making sure that all is square. Mount the rest of the screens working outwards from the centre but only tack the screens together at this point in case any have to be adjusted slightly. It can be very difficult to unsolder a completed joint! When you are sure that all is well, run the soldering iron, preceded by the solder, along the joints. The other side can now be offered up and, again, tacked on until you are happy with the alignment after which you can complete the joints. Unless you are extremely lucky the individual top screens will not fit, so each one has to be filed to size to make them a push fit. Solder a short length of 16 SWG wire to one face of the screen to enable it to be located (and later removed) during fitting and fixing. Round off the corners slightly so that any solder that is in the way in the corners of the box does not prevent location of the screens.

CAPACITOR PLATES

The capacitor plates should be made to a tolerance of +0, -0.02", so this is where the use of calibrated calipers can prove very handy. The centre hole is located in the same way as the holes in the screens and drilled with a number 32 drill (6BA clearance). The plates must have all the burrs removed and the corners rounded off using a fine file or coarse glass paper. The faces are then rubbed on the glass paper until it is seen that all of the surface is in contact. Fortunately it is only necessary to carry out this nail-breaking performance on one face!

The PTFE sheet is cut 5/16" larger than the plates, four being needed for each capacitor, ie. two per plate. The centre hole is made by holding the sheet over the hole in the plate and pushing a 1/8" screwdriver through the hole, a pair of sidecutters is then used to trim off the small piece of material that remains.

Before assembly of the capacitor plates be absolutely certain that all traces of swarf and filings are removed from the component parts as any trace of metal could cause the dielectric to break down. Wash the housing in warm soapy water, rinse and dry off thoroughly. If you intend to dry off the assembly using an oven, do please remember the low melting point of solder! The plates are fixed by 1/2" 6BA screws, nuts and shake proof washers with a solder tag on each side. Mount the inner ones first because it is then possible to reach the screw heads through the outer screens.

The coils should be made exactly in the manner described in order to obtain the correct filter response. I tried two sets of coils, one made by myself and another prepared by a friend to my instructions, both sets produced exactly the same filter characteristics. The idea of this exercise was to verify that the design could be reproduced without the need for tweaking. The formula used for the calculation of the capacitor plate sizes was taken from the *ARRL Handbook*, 1988, and is:

$$C = 0.224.k.A/d$$

Where C is in pF, A is the area of one plate in square inches, d is the thickness of the dielectric in inches and k is the dielectric constant of the PTFE. Both the accuracy of the formula and my calculations were checked on an accurate bridge.

The coils are made using 16SWG tinned copper wire by winding 9 turns on a 1/2" former, then removing the coil and running a 1/8" screwdriver through the turns. One turn is removed so that there are 8 left, at which point the length of the coil will be too large. Compress the winding using finger and thumb and the end result should be a length of 1".

The coils, L1, 2 and 3, are now soldered into place, carefully bending the solder tags to fit on the end of the winding, without compression or expansion of the coil. Before the individual top screens are soldered into position test the filter in the output of your transmitter and gradually increase the power to maximum. With a bit of luck and a following wind there will be no sparks or bangs!

If all is well, the top screens can now be soldered into position. They are inserted to a depth such that there is a sufficient strip of copper, about 1mm, to enable a run of solder to be made along the four sides. The lid is drilled with a No 60 drill in five places along each edge, about 0.4" in, and links soldered into position through the board. Offer up the lid and make any fine adjustments to the size so that it seats correctly. Using copper foil, fix the lid to the main frame in four places along each edge and one at each end. This completes the testing and construction of the filter. □

Fig 1.(above) Mechanical construction of the filter.

Fig 2.(below) Plate capacitor construction detail.

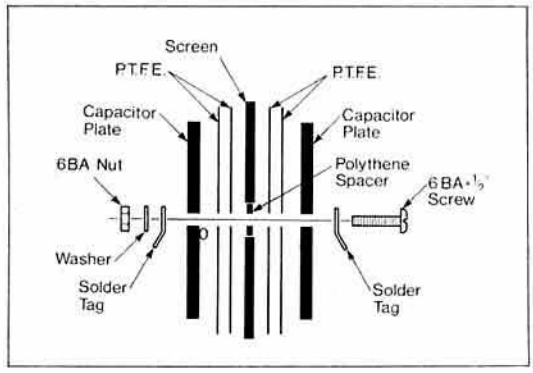


TABLE 1
(All dimensions in inches)

Base and Sides	8.5 × 2.7"
Lid	8.5 × 2.5"
Screens	2.5 × 2.5"
End Screens	2.8 × 2.7"
Top Screens (nominal)	2.6 × 2.2"
C1, 4 Plates	1.5 × 1.5 + 0.0/-0.02"
C2, 3 Plates	2.1 × 2.1 + 0.0/-0.02"
L1, 2, 3	See text

FILTER SPECIFICATION

Passband Insertion Loss	0.37dB at 29MHz
Stop-band Max Attenuation	>60dB
SWR at 14MHz	1.26:1
SWR at 29MHz	1.78:1
Rejection at 42MHz	28dB